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Aspects of the Host Commensal Relationship between a Palaemonid Shrimp ('Pontonia domestica') and the Pen Shell ('Atrina rigida')

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16. ABSTRACT

Sixty pen shells (Atrina rigida), were collected and examined to determine the prevalence and morphometrics of the commensal shrimp (Pontonia domestica). The spatial and sexual distribution within the shell of the host, and the reproductive states of the shrimp were also investigated.

17. KEY WORDS AND DOCUMENT ANALYSIS

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ASPECTS OF THE HOST—COMMENSAL RELATIONSHIP BETWEEN A PALAEMONID SHRIMP (*Pontonia domestica*) AND THE PEN SHELL (*Atrina rigida*)

The Pen Shell, *Atrina rigida* (family Pinnidae), can be found partially buried in the sandy bottom of the coastal Gulf of Mexico and Atlantic waters. These endobyssates anchor themselves by attaching to small stones, shells or other objects by means of byssal threads secreted by the byssal gland. Because of their behavior and habitat, collection of the living organism can be a long tedious process, requiring many hours of diving or dredging. In September 1979, after Hurricane Frederic passed across the coast of Florida, Alabama and Mississippi, we had the opportunity to collect a relatively large number (60) of the living organisms that had been dislodged from the Gulf bottom and deposited on the beach by the storm.

These mollusks are of special interest because a small commensal palaemonid shrimp (*Pontonia domestica*) lives within the bivalve's shell. Little is known about the host-commensal relationship between *Atrina* and *Pontonia*. Most information available on related commensal caridean shrimp is found in studies on western Indian Ocean and Indo-West Pacific species. Bruce (1976) reported five pontoniine genera (*Anchistus* Borradaile, *Chernocaris* Johnson, *Conchodytes* Peters, *Paranchistus* Holthuis, and *Platypontonia* Bruce) as commensals of pelecypods (host families: Pinnidae, Tridacnidae, Ostreidae, Pectinidae, and Spondylidae). Interestingly, no other famiy of shrimp has been reported in association with a pelecypod host (Bruce 1976). Additional information on western Indian Ocean and Indo-West Pacific species can be found in reviews by Balss (1966), Borradaile (1917), Holthuis (1952), Kemp (1922), and Patton (1966, 1967). With regard to Western Atlantic species, existing reviews include Holthuis (1951), Williams (1965), and Chace (1972). Chace (1972) reports at least three species of *Pontonia* associated with various mollusks (*Atrina, Pecten, Aequipecten, Pteria, Pinctada,* and *Astrophyton*). *Pontonia domestica* has been reported from *Atrina seminuda, A. serrata,* and *Pecten* sp. (Williams 1965, Holthuis 1951). An excellent series of articles detailing the host-commensal relationship between a pontoniine shrimp and a pinnid mollusk is provided by Regine Hipeau-Jacquotte (1971, 1972, 1973, 1974a, 1974b, 1974c). The species dealt with in this series are from Madagascar, however the information is widely applicable.

The availability of a large number of bivalves (*Atrina rigida*) permitted a study of the prevalence, morphometrics, spatial and sexual distribution of *Pontonia* within the shell of its host, and the reproductive status of the shrimp.

MATERIALS AND METHODS

Pen Shells were collected on the Gulf beach of Santa Rosa Island approximately seven miles east of Pensacola Pass near Pensacola, Florida, an area on the eastern fringes of Hurricane Frederic's landfall. Collections were made September 13, 1979, the day following Frederick's arrival. Tidal surge in this vicinity was approximately 3 meters above normal and maximum sustained winds were 86 kph with gusts up to 154 kph. These conditions, combined with 3 to 5 meter wave action, dislodged large numbers of Pen Shells from the bottom and deposited them on the beach. Some mollusks found were in a weakened condition, showing signs of dehydration and impaired adductor muscle response. However, most

of the bivalves were still alive and able to keep their valves tightly closed, only those in this condition were sampled. The mollusks were carefully measured (length, width, and depth) and then opened using a knife to sever the adductor muscles, taking care not to disturb the contents. Palaemonid shrimp found living within the bivalves were counted and the location of each, in relation to the bivalve's body, was noted. All shrimp were sexed (notation made of all gravid females) and total length (from the tip of the rostrum to the tip of the telson, along the dorsal midline) measured.

Sex was determined by examination of the second pleopod of each shrimp under a dissecting microscope. The presence of an appendix masculina on the second pleopod denoted a male shrimp; of only an appendix interna, a female (Williams, 1965). Microscopic examinations for eggs on the underside of the abdominal segments of each shrimp determined ovigerous females. Shrimp were fixed in Davidson's fixative for future use and confirmatory identification. Specimens were submitted to and retained by the Smithsonian Institute's National Museum of Natural History.

RESULTS AND DISCUSSION

A total of 60 bivalves, positively identified as *Atrina rigida*, the Stiff Pen Shell, were examined. This species is commonly found from North Carolina to Florida and in the Caribbean. The mollusks had a mean length of 18.0 cm (range 10.6 — 23.1 cm), a mean width of 8.6 cm (range 4.3 — 12.3 cm), and a mean depth of 3.5 cm (range 1.9 — 5.3 cm).

A commensal shrimp of the genus *Pontonia* was found living within many of the bivalves examined. The identification of this shrimp was confirmed by Dr. C.W. Hart, Jr. at the National Museum of Natural History as *Pontonia domestica* Gibbes, a species known to range in the western Atlantic from the coast of North Carolina to Louisiana including the Bahamas (Williams, 1965).

A total of 86 shrimp were found within the 60 bivalves examined. Fifty-one mollusks harbored shrimp, an association rate of 85%. Of the bivalves which contained shrimp, 56.9% contained two, 37.2% harbored only one, and 5.9% were inhibited by three shrimp. No more than three shrimp were found in any of the bivalves examined.

Data on the distribution of the shrimp within the shell valves, as well as their sex and reproductive status were gathered. Figure 1 presents a diagrammatic representation of the general areas in which shrimp were found within the shells. The four areas (A, B, C and D) within the shaded portion (Area I) represent locations within the branchial chamber. Shrimp found in these locations were nestled among the gill filaments, totally enclosed by the mantle. Shrimp found in areas E, F, G, and H (Area II) were found either outside the mantle, in the cavity between the shell and body of the mollusk, or at the very periphery of the mantle cavity. Actual numbers and percentages of shrimp categorized by sex and reproductive state from each location (A through H, Figure 1) and from the shaded and non-shaded areas (Area I and II, Figure 1) are presented in Table 1.

The majority (73.7%) of male shrimp were located in the shell cavity and periphery of the mantle cavity (Area II). Twenty (71.4%) of the male shrimp found in this area (52.6% of all males) were located along the posterior edge of the shell cavity (Fig. 1, F). The posterior edge of the shell is the only portion exposed above the substrate when the mollusks are in their normal habitat. Six additional male shrimp were found in area G (Fig. 1). The remaining males were distributed fairly evenly throughout the rest of the

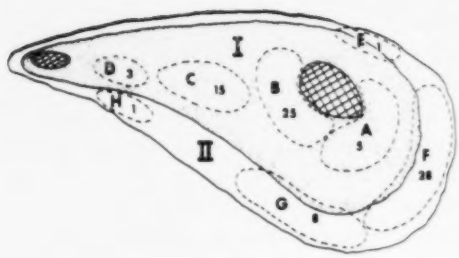

Figure 1. Diagram of Pen Shell (*Atrina rigida*) showing spatial relationships and locations in which commensal shrimp (*Pontonia domestica*) were found. Stippled area (I) represents body proper of mollusk. The unstippled region (II) represents areas within the shell valve not enclosed by the mantle. Numbers associated with each lettered area denote total numbers of shrimp found in each location. Large crosshatched area is the posterior adductor muscle; small cross-hatched area, the anterior adductor muscle.

shell.

Distribution of the females as a whole was approximately the converse of that of the males (79.2% in Area I and 20.8% in Area II). Non-gravid females were almost evenly distributed between the two areas (58.8% in I, 41.2% in II), however, gravid females showed a strong preference (90.3%) for Area I, where they were found nestled in the gill filaments, most (64.5%) close to the posterior adductor muscle (location B). This positioning offers a highly protected location and probably the most advantageous location for feeding. Hipeau-Jacquotte (1972) reported on food collection and feeding relationships between pontoniine shrimp and pinnid mollusks. Water, containing particles of food, is pumped through the branchial chamber by the mollusk. The food particles are trapped in the mucus coating lining the mollusk's tissues and the shrimp then feeds upon the mucus and captured organic matter. While the species dealt with in this paper differ from those discussed by Hipeau-Jacquotte, the feeding mechanisms used in the *Pontonia domestica/Atrina rigida* relationship are probably similar to those he described. Additional work on this aspect of the host-commensal relationship is needed to confirm or refute this hypothesis.

The sexual ratio for the 86 shrimp collected was 48 females to 38 males. Of the females, 64.6% were gravid, indicating that mid-September, the time of collection, is an active reproductive period for this species in the northern Gulf of Mexico.

Considering the spatial distribution of all *Pontonia* within the sampled *Atrina*, we see a relatively even distribution between Areas I and II (55.8% and 44.2%

Table 1. Numbers and percentages of shrimp (*Pontonia domestica*) found in Pen Shell (*Atrina rigida*). Data are categorized by sex, reproductive state of females (gravid or non-gravid), and area (I or II) and location (A-H) found in Figure 1.

AREA	LOCATION	MALES	FEMALES GRAVID	FEMALES NON-GRAVID	TOTAL	ALL SHRIMP
	A	5 (13.2%)	.....	.....	.....	5 (5.8%)
	B	.....	20 (64.5%)	5 (29.4%)	25 (52.1%)	25 (29.1%)
I	C	4 (10.5%)	8 (25.8%)	3 (17.6%)	11 (22.9%)	15 (17.4%)
	D	1 (2.6%)	.....	2 (11.8%)	2 (4.2%)	3 (3.5%)
Subtotal	I	10 (26.3%)	28 (90.3%)	10 (58.8%)	38 (79.2%)	48 (55.8%)
	E	1 (2.6%)	.....	.....	.....	1 (1.2%)
	F	20 (52.6%)	3 (9.7%)	5 (29.4%)	8 (16.7%)	28 (32.6%)
II	G	6 (15.8%)	.....	2 (11.8%)	2 (4.2%)	8 (9.3%)
	H	1 (2.6%)	.....	.....	.....	1 (1.2%)
Subtotal	II	28 (73.7%)	3 (9.7%)	7 (41.2%)	10 (20.8%)	38 (44.2%)
Total (I and II)		38 (100%)	31 (100%)	17 (100%)	48 (100%)	86 (100%)
Percentage of all shrimp		38 (44.2%)	31 (36.0%)	17 (19.8%)	48 (55.8%)	86 (100%)

respectively). However, looking at sexual distribution with regard to numbers of shrimp found within a given bivalve, we note some interesting trends. Twenty-nine mollusks contained two shrimp. Of these, only two mollusks contained shrimp of the same sex (females in both cases), leaving 93.1% of the two-shrimp bivalves containing male/female pairs. In addition, of the three mollusks containing three shrimp, members of both sexes were present in each. Finally, of the 19 bivalves that harbored only one shrimp, the majority, 13 (68.4%), contained single females and only 6 (31.6%) contained single males. No juveniles were noted in the shrimp sampled.

These data and those on location of the shrimp within *Atrina* allow the following inferences. First, it appears that the shrimp tended to reside in male/female pairs (58.8% of the bivalves containing shrimp contained both sexes), and that these pairs were probably mated (in 66.7% of the male/female pairs the females were gravid). Furthermore, the majority of the male shrimp (52.6%) were located along the posterior edge of the shell cavity (Fig. 1, F), the only portion of the shell exposed above the substrate in which the bivalves burrow, a position offering easy access to the exterior environment. This information and the fact that most of the singly inhabited mollusks contained females (68.4%) could indicate that male shrimp are more motile than females, perhaps moving from bivalve to bivalve in a given area. Similarly, females tended to be located deep within the protected confines of the Pen Shell's gill complex (79.2% of females were found in locations B, C, and D, Fig. 1). This was especially evident in the gravid females, 90.3% of which were found among the bivalve's gill structure. This information and the fact that most of the singly inhabited mollusks contained females suggest that females are relatively non-motile.

Table 2 summarizes the size data collected on *Pontonia*. The largest male shrimp found was 30.4 mm in total length, mean size for males was 23.8 mm. The largest females recorded were 32.8 mm in length; a gravid and non-gravid female of this length were found. The mean size of ovigerous females was 26.5 mm, mean size of non-gravid females was 23.5 mm, and the mean length of all females was 25.4 mm. Statistical analysis of the shrimp size data was performed, using one-way analysis of variance (ANOVA) and the F-test to determine if there were any significant differences between the groups, followed by a Student-Newman-Keul or Duncan's Test to determine which groups were significantly different. The analyses indicated a significant size difference (at 95% confidence limits) between the males and females as a whole, the females being slightly larger. In addition, significant differences were noted between males and gravid females and between non-gravid and gravid females. No significant size difference was found between the males and non-gravid females.

No gross signs of pathology were noted on examination of the mollusks' tissues. However, we were unable to perform histological examinations of the tissues to determine actual effects of the

Table 2. Mean total length and size range of 86 shrimp (*Pontonia domestica*) collected from Pen Shell (*Atrina rigida*). Significant differences at 95% confidence limits (using ANOVA, F-test, and Duncan's test analyses) were found between males and all females, between males and gravid females, and between non-gravid and gravid females. No significant size difference was found between males and non-gravid females.

SHRIMP CATEGORY	MEAN TOTAL LENGTH (mm) AND RANGE
Males (n=38)	23.8 (16.8-30.4)
All Females (n=48)	25.4 (16.7-32.8)
Gravid Females (n=31)	26.5 (18.9-32.8)
Non-gravid Females (n=17)	23.5 (16.7-32.8)

shrimp's presence within the host.

Some artifacts may exist in the data on spatial distribution and possibly even prevalence. The method of collection (i.e. storm) could possibly have caused stresses affecting shrimp distribution within the host and perhaps even separating some shrimp from their hosts. However, most collection methods (i.e. dredging, trawl) would introduce similar stresses, even manual collection using diving would involve manipulations which could affect such data. Nevertheless, the data display consistencies indicating these stresses played a minor role. They are presented, therefore, cum caveat, for the use of future investigators.

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